TREATMENTS OF METAL SURFACES TO IMPROVE BAL SEAL® SPRING-ENERGIZED SEAL PERFORMANCE IN DYNAMIC APPLICATIONS

Technical Report
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1.0 DISCUSSION

The hardness of the material that a BAL™ Seal comes in contact with affects its performance substantially.

Various processes are available, depending on the material and the properties desired, designed to increase such hardness. It is very desirable to have a high hardness on the metal surface since it reduces the adhesion between the seal and the sealing surface, resulting in substantially lower friction and lower wear of the seal.

2.0 TYPICAL SURFACE TREATMENTS OF METAL SURFACES USED IN CONTACT WITH BAL SEALS

The processes used will depend to a great extent on the material and the overall properties desired. The chart describes some of the processes and properties most commonly used. (See page 6)

3.0 DESCRIPTION AND APPLICATIONS

The following is a brief, general description of the various processes and applications.

3.1 Hard anodizing

3.1.1 Description

This is an electrolytic process that deposits an aluminum oxide coating (AL_2O_3) on the surface of aluminum and achieves an equivalent Rockwell C surface hardness of 60 – 65. This process results in a coarse surface structure and requires further machining to smooth the surface irregularities to reduce abrasion of the BAL Seal. The average coating thickness per side should be between 0.0003 to 0.0008 inch (0.0076 to 0.0203 mm).

3.1.2 Application of dry lubricants

Hard anodizing produces a porous surface with crevices that permit good adherence of dry lubricants, such as: graphite, molydisulfide, PTFE, etc., which are very desirable, where no wet or dry results in lower adhesion between sealing surfaces with lower friction and better seal performance.

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3.2 Chrome plating

3.2.1 Description

This is an electrolytical process that deposits hard chrome on the surface. It should be noted that chrome migrates primarily onto the peaks of the metal surface irregularities, thus roughening the surface finish and requiring additional finishing after plating.

Chrome plating provides a dense, hard surface, which is highly wear resistant and very suitable for those applications requiring long seal performance. It also provides a slick surface, which results in low stick-slip and low coefficient of friction, which promotes long seal life. It should be noted that chrome plating is porous and not suitable for corrosive service.

Hard chrome plating is very hard with a surface hardness from 65 to 68 Rockwell C equivalent and has a rough surface finish to reduce abrasion of the BAL Seal. This fact is critical in high pressure or high-speed application. The average coating thickness per side should be between 0.0005 to 0.001 inch (0,0127 to 0,0254 mm).

3.2.2 Application of dry lubricants

Dry lubricants may be applied on the chrome-plated surface, especially if no additional surface improvement is done. However, it's recommended that a good surface finish be provided in preference to the application of dry lubricants. The application of dry lubricants may serve two objectives: provide lubrication and improve surface finish by filling the various surface irregularities, thereby improving BAL Seal performance.

3.3 Electroless nickel plating

3.3.1 Description

This is a chemically deposited nickel alloy that can be applied to many metallic surfaces. Electroless nickel plating requires a subsequent heat treatment to 750°F for about one (1) hour to achieve a hardness equivalent of 58 to 64 Rockwell C hardness.

Electroless nickel has the unique advantage that it provides a porous-free structure with uniform deposition, thus maintaining approximately the same surface finish before and after plating and heat treatment. It also provides very good corrosion resistance. In order to provide good bonding, it is necessary to glass bead the surface prior to plating, thus creating a coarse finish that may require subsequent honing, polishing or lapping after plating and heat treating. The electroless nickel matrix is non-uniform   having some very hard areas on a softer nickel matrix, thus having a greater tendency to wear.

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The average coating thickness should be between 0.0003 to 0.0008 inch (0,0076 to 0,0203 mm). Non-heat treated electroless nickel plating achieves a hardness of approximately Rockwell C 50 equivalent, with substantially greater wear of the plated surface and BAL Seal.

3.3.2 Application of dry lubricants

Dry lubricants are not recommended on electroless nickel-plating because of the poor adhesion with the uniform, porous-free nickel base surface.

3.4 Plasma spray coatings

3.4.1 Description

This type of coating consists of the application of powders such as chromium oxide, aluminum oxide, tungsten carbide, etc. under conditions of high temperature and speed on a metallic surface by depositing a layer of the powder material selected. The properties of the coating vary, depending on the material and application process used, but generally, it provides an extremely hard coating with a nodular surface structure that minimizes BAL Seal abrasion. The coating hardness varies, depending on the material selected, but can be as high as 74 Rockwell C equivalent for chromium oxide coatings. Application of the coating is non-uniform, thus requiring honing or lapping to provide an adequate surface finish for use in contact with Bal Seals to assure a better degree of performance.

Thickness of coating should be between 0.001 to 0.003 inch (0,0025 to 0,076 mm) per side with subsequent finishing.

3.4.2 Types of coatings

Various types of coating materials are available, and the ones suggested for use with Bal Seals are:

a. Chromium oxide
b. Aluminum oxide
c. Tungsten carbide

Chromium oxide is used whenever a very high degree of hardness and wear resistance is required, as for example, when in contact with very abrasive materials.

Aluminum oxide combines wear resistance with greater ductility than chromium oxide.

Tungsten carbide is used when a greater degree of flexibility is desired, as in those applications involving shaft flexibility.

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3.4.3 Application of dry lubricants

Plasma sprayed coatings have a porous structure and lend themselves to the application and good retention of graphite, molydisulfide, PTFE and others. The added lubricants tend to seal the pores, which enhances sealing ability, provides self-releasing properties, reduces friction, and improves corrosion resistance.

VARIOUS SURFACE TREATMENTS OF METAL SURFACES AND PROPERTIES

SURFACE TREAT-MENT	MATERIAL	ESTIMATED ROCKWELL C HARDNESS	CORROSION RESISTANCE	PROCESS SPECIFICA-TION	SURFACE FINISH AFTER TREATMENT	TYPICAL THICKNESS SIDE	SUGGESTED SURFACE FINISH	DRY LUBRICANT ADHERENCE
HARD ANODIZ-ING *Request TR-17*	Aluminum	60-65	Fair	MIL-A-8825 Type 3	Coarser	0.0003 to 0.0008 in. (0,0076 to 0,0203 mm)	4-8 RMS (0.091 to 0.183 microns)	Very Good
CHROME PLATING *Request TR-14*	Ferrous and some non-ferrous metals	65-68 (Vickers 800)	Fair	QC-C-320 Class 2A	Coarser	0.0005 to 0.0010 in. (0,0127 to 0,0254 mm)	4-8 RMS (0.091 to 0.183 microns)	Good
ELECTRO LESS NICKEL PLATING *Request TR-16*	Ferrous and Non-ferrous metals	48-52 (Vickers 800) 58-64 (with heat-treated	Very good	MIL-C-260-74C Class 2A	Same	0.0005 to 0.0008 in. (0.0076 to 0.0203 mm)	4-12 RMS (0.091 to 0.275 microns)	Poor
PLASMA *Request TR-34*	Steels	65-74 (Vickers 800-1200)	Fair	None	Coarser *But depends On Application*	0.001 to 0.003 in. (0.025 to 0.076 mm)	4-12 RMS (0.091 to 0.275 microns)	Very Good

It should be noted that many processes roughen the surface finish, requiring additional honing, polishing, or lapping after processing.

Chart Showing Different Surface Treatments Used to Increase Surface Hardness
Figure 1